CONVENTIONAL OIL AND GAS, GEOPHYSICAL EXPLORATION

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BUILDING BLOCKS FOR ECONOMIC DEVELOPMENT & ANALYSIS

PREFACE

PURPOSE

Building Blocks have been conceived and developed by the Economic Development Branch of the Ministry of Sustainable Resource Management, under the guidance of Nancy South, Manager Economic Analysis, as an analytical tool that supports British Columbia coastal and land and resource use planning and decision-making and economic development initiatives. The Blocks contain concise business and sector information for a broad range of resource-based business types in BC. At this point, there are more than 30 Blocks either complete or in draft form. Several more Blocks have been identified as high priority by planning tables and other client groups. Additional Building Blocks will be developed over time, and some Blocks may be updated. For the most current Building Blocks, please see the Ministry of Sustainable Resource Management website, at: http://srmwww.gov.bc.ca/rmd/ecdev/

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BENEFITS

Building Blocks are expected to provide the following general benefits:

- Increase efficiency and more informed decision-making by providing readily accessible, credible information to planning and economic development processes;
- Improve the consistency of economic information across planning areas;
- Support economic analysis and decision-making that occurs outside formal coastal and land use planning processes; and
- Provide linkages between economic analysis and other social and environmental analytical tools (through identifying resource requirements to support economic activities and general compatibilities with other sectors and values).

LIMITATIONS

Every effort has been made to ensure that the information contained in Building Blocks is accurate and consistent. Approved, credible data sources are the foundation for Building Blocks. All Blocks were reviewed by sponsoring agencies and other experts. However, users are cautioned that information is used at their own risk, and that the authors and sponsors are not liable for any damages. Any conclusions or interpretations by the authors are not intended to represent government policy. Also, note that Building Blocks do not provide site specific information nor do they consider requirements for sustainability (social, community, environmental).

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RECOMMENDED REFERENCE/CITATION

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TABLE OF CONTENTS

1.0 OVERVIEW 1

1.1 Description 1
1.2 Industry Components 1
1.3 Geophysical Exploration - Details 3

2.0 LAND RESOURCE REQUIREMENTS/SENSITIVITIES 4

2.1 Provincial Crown and Other Resources Required to Support Business 4
2.2 Complementary/Conflicting Relationships with Other Resource Values 4

3.0 INVESTMENT REQUIREMENTS 5

3.1 Capital (Start-up) Costs 5

4.0 INFRASTRUCTURE 7

4.1 Overview 7

5.0 MARKET 7

6.0 LABOUR FORCE 8

7.0 CAPACITY 9

7.1 Resource Capacity 9
7.2 Commercial Capacity 10

8.0 REGULATORY REGIME 10

8.1 Overview 10
8.2 Provincial 11
8.3 Private Land 11
8.4 First Nations 11
8.5 Parks and Environmentally-Sensitive Areas 11
8.6 Federal Government 12
8.7 Timing 12

9.0 GOVERNMENT REVENUES 13

9.1 Municipal 13
9.2 Provincial 13
9.3 Federal 14

10.0 INPUT-OUTPUT TABLE 14

11.0 REGIONAL COST VARIATIONS 15

11.1 Regions 15
11.2 Regional Data 15
11.3 Pre-tenure Planning 15
11.4 Evolution of Immature Basins to Mature Producing Regions 16
11.5 Opportunities 16
11.6 Challenges 17

REFERENCES 17

1.0 OVERVIEW

1.1 Description

British Columbia is the second largest natural gas producing province in Canada and accounts for 13% of Canada's production. Most petroleum activity takes place in the northeastern section of the province. Large, world-class natural gas discoveries have focused significant interest in this area. Industry expenditures in British Columbia reached $4.3 billion and a record number of wells (850) were drilled in 2001. Crude oil and condensate production, and natural gas production in 2001 were 2687 10^3m^3 and 29.9 10^9m^3, respectively. The sales value of this production was around $5.6 billion. Direct revenues from royalties and oil and gas rights were $1.7 billion.

1.2 Industry Components

The exploration and development of oil and gas is a capital-intensive process that from the onset is focused on producing hydrocarbons to a sales point in the shortest and most profitable manner. Following is a description of exploration and development elements and decision processes. Information related to the maturing and production of resource basins can be found in the Appendix.

Wide Area Geological Review (conducted in corporate head offices, normally located in Calgary or foreign countries):

- Publicly available geological and geophysical data and information from data vendors are investigated. Seismic data can be purchased from data vendors in a raw or processed form.
- Geologists and geophysicists begin by researching data made available by governments.
- Government data includes subsurface electronic well logs, drilling reports and oil and gas production reports.

Acquiring Oil and Gas Rights - Proposals and Decisions (typically made in Calgary; some decisions include review by foreign offices):

- A company will usually participate in a tenure competition with other partners. Companies seek out partners to reduce their risk.
- Companies bid on the basis of their wide area geologic review. The level of bonus paid is dependent on the estimated quantity of gas or oil, the cost and timing to drill a well, the royalty and taxes payable to the Crown, the proximity to a pipeline and plant infrastructure, and the expected price that can be realized at the nearest sales point. This information is processed in economic models that assist in determining the level of bonus paid to the Crown.

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The following three activities all require surface land access, through agreements with the Crown or landowner, in the case of private land.

Geophysical Exploration (decisions on geophysical contracts and programs are usually made in Calgary):

- Geophysical technology greatly reduces the risk of drilling. Wells are drilled to test a geological theory or model that is generated in the Wide Area Geological Review and validated by seismic data. The relative position of rock layers can be imaged from the patterns of acoustic sound waves that are reflected from subsurface formations.
- For two-dimensional (2D) seismic operations, field crews run parallel lines of sound recorders at wide intervals to cover large areas in a relatively inexpensive manner.
- Once a field is discovered, 3D seismic can be run in a grid pattern with close sound recorders to delineate the most attractive places to drill additional wells and determine the areal extent of a formation.

Drilling (drilling contractor selection may be done in Calgary; supervision in Fort St. John):

- Initial activities are road, site and well location surveying, followed by road and lease clearing, grading and applying gravel.
- The drilling rig is moved on site and crews work 24 hours a day to drill a hole ranging in depth from about 1000 metres to 3000 metres.
- Once the hole has been drilled to the target formation, the well is logged with electronic downhole measurement tools to record the characteristics of the subsurface rock formations.
- If logging indicates the well is productive, it is cased with steel pipe and a wellhead of shutoff valves is installed to prepare for production. The well is completed by perforating holes in the casing at the depth of the producing formation.

Gathering and Processing Systems and Facilities (designing is typically done in Calgary; project management and decisions on contracts can be made at regional offices such as Fort St. John):

- Pipeline connections to gas wells are necessary linkages to gas processing plants and wide-area transmission lines. Oil wells are typically connected by pipelines to treating facilities. Oil can be trucked from remote or low productivity wells that do not economically support pipelines.
- Gas plants remove sour gas (hydrogen sulphide [H_2S]), carbon dioxide, nitrogen and water from raw gas.
- Oil facilities, typically called oil batteries, remove natural gas and water from the oil stream prior to transport via oil transmission lines.

Abandonment and Reclamation

After wells are shut in, well casings are sealed and cut off below surface to abandon the wells. Surface sites and pipeline rights-of-way are reclaimed. Pipelines are abandoned by displacing hydrocarbons, filling the pipe with inhibited water and cutting off surface risers. Eventually wellsites, cut lines and roads are returned to a state that can sustain native vegetation.

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The information presented above describes what is known as the "upstream sector" of the oil and gas industry. The midstream and downstream sectors, which are beyond the scope of the Conventional Oil and Gas building blocks, are described below.

Midstream Sector

This sector consists of pipeline systems that connect producing and consuming areas. Other midstream facilities extract sulphur and natural gas liquids (NGLs), store products, and transport products by truck, rail or tanker. Gas transported via major transmission pipelines is typically comprised of methane and ethane. (Propane, butane and other NGLs are removed and stored before entering a gas transmission line.)

Downstream Sector

This sector consists of refineries, gas distribution utilities, oil product wholesalers, service stations and petrochemical companies.

1.3 Geophysical Exploration - Details

This building block addresses geophysical exploration, which is the first element of oil and gas exploration that has a direct impact on the land surface. Building blocks that address tenure acquisition and drilling, and gathering and processing systems and facilities have also been developed. Production revenue has been captured in the latter building block.

Geophysical exploration normally consists of clearing lines to allow the setting of acoustic recorders, detonating dynamite charges or conducting mechanical *vibroseis*, and recording acoustic signals reflected from subsurface formations. (The vibroseis method sends energy waves from a heavy, vibrating vehicle into the earth and can be conducted in agri-roaded areas). Low-impact seismic (LIS) avoidance techniques (see below) are used in sensitive areas, such as the Foothills region. Aeromagnetic, airborne gravity and geochem surveys may be used in severe foothills environments to avoid any ground disturbance.

Preliminary analysis of the digital information may be performed in the office locations of the geophysical company. Specialized software is used to process the data to find suitable traps for oil and gas. In some cases, several lines of recorders are used to create a 3D image of the geology.

Industry Structure and Activity

- The majority of geophysical companies are in oil industry towns; Fort St. John is the predominant location in British Columbia.
- Certain brush clearing activities may be subcontracted to local forestry subcontractors.
- Road improvement and new construction may be required to access the seismic locations.
- Seismic vehicles are large trucks that require reasonable road access.
- The impact on the environment can be reduced with narrower cutlines, helicopter transport of the seismic equipment and satellite techniques. LIS avoidance techniques minimize disturbance to ground cover. Lines are typically created using hand cuts or small mechanical equipment and have a width of less than 4.5 m.

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- Line width depends upon cutting method, timber type, density, and snow cover depths. LIS may include heliportable portions with a handcut line 1.5 m wide.
- In heavily treed stands, or in wetlands where meandering may create a fire hazard or damage more vegetation than straight cut, lines are cut with deliberate line-of-sight blockages every 200 m. Wheeled, low-ground-pressure or track vehicles are usually used on these lines.
- In addition to hand-cutting lines, LIS avoidance can be assisted by helicopter through heli-drilling and heli-recording.

Primary Activities

- Access
  - road building and road improvement
  - clearing of cut-lines to allow passage of seismic trucks or vehicles
- Seismic Collection
  - stringing of continuous seismic wires that connect acoustic receivers
  - detonation of small explosive charge or mechanical vibration
  - field recording of information gathered at each receiver along the seismic line
  - retrieval of seismic recorders and return of electronic data to office location
- Data Processing
  - preliminary data processing is done at the office location.
  - sophisticated analysis of the information is normally done at the head office of the geophysical contractor prior to forwarding the data to an oil and gas exploration company.

2.0 LAND RESOURCE REQUIREMENTS/SENSITIVITIES

2.1 Provincial Crown and Other Resources Required to Support Business

- sub-surface tenure under the *Petroleum and Natural Gas (P&NG) Act*
- surface rights (under the *Land Act* or from the landowner)
- efficient, cost-effective access
- Provincial forest
- rangeland
- designated land use areas
- Agricultural Land Reserve

2.2 Complementary/Conflicting Relationships with Other Resource Values

Although geophysical exploration may affect other resources, permit and application review processes that take into consideration other resource values have been put in place to minimize or mitigate potential effects. Following are lists of issues that are addressed before geophysical operations can proceed.

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Complementary Relationships

- Seismic cut-lines can provide wildlife corridors and new access for recreation users and guide outfitters, trappers, residents, and communities.
- New access can increase the potential for forest, mineral and utility development and tourism.

Possible Resource Conflicts

- Archaeological Sites – Improper line selection can cause disturbance to archaeological sites and heritage resources, including heritage rivers.
- Ecosystems – The area may be impacted by alteration of drainage patterns, disturbance to native vegetation, surface disturbance and erosion, and the introduction of noxious weed species.
- First Nations – Activities may affect historical and current uses (e.g., spiritual, gathering and hunting sites) and/or areas used to exercise treaty or aboriginal rights. Companies and First Nations may enter discussions to identify ways to avoid or mitigate impacts.
- Fish – Alteration of drainage patterns and erosion can impact watercourses and destroy fish or fish habitat.
- Forestry – The clearing of cut-lines can result in a loss of timber resources, particularly if the timber quantity is uneconomic to recover.
- Water – Improper shot-hole drilling and recording may result in contamination of surface water and groundwater and disruption to groundwater flows.
- Wilderness – Wilderness values for areas, currently accessible only on foot or horseback, can be lost once new access and cut-lines have been introduced.
- Wildlife – The clearing of seismic lines can alter and fragment habitat, and create access and linear sight-lines, increasing the potential for adverse impacts on wildlife populations, particularly during sensitive breeding, rearing or wintering periods.

Other Issues

- In addition to the potential resource conflicts listed above, geophysical contractors must take precautions to avoid damaging buried underground hazards (e.g., powerlines and oil and gas pipelines) and improperly disposing of seismic and camp wastes.

3.0 INVESTMENT REQUIREMENTS

3.1 Capital (Start-up) Costs

The amount the industry spends on geological and geophysical exploration in British Columbia in a given year depends on a variety of factors, including commodity prices, the investment environment and corporate priorities. In the 10-year period from 1991 to 2000, the range was from $51.3 to 130.2 million, with the peak occurring in 1994. However, the ratio of geological and geophysical exploration to total exploration, development and operating expenditures has declined from around 12% in 1991, to as low as 3% in the last few years. Crew-weeks worked has also declined from around 300 in 1991, to a low of 105 in 1999.

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Following are geophysical (seismic*) costs (including interpretation and processing, where applicable) for the Prairie provinces. An additional 10-20% should be added on to account for the remoteness of British Columbia relative to the Prairie Provinces. LIS avoidance seismic can cost significantly more than conventional seismic. The cost of conventional programs and LIS can vary widely and from year to year. The cost of a program depends on the technique(s) used, size of program, area, time of year and jurisdiction. A 2D program can range from several kilometres to a hundred kilometres, if it is focusing on a large region. A 3D program can also vary in size, from under 50 km^2, to several hundred km^2. The larger programs are normally shot by speculative seismic companies.

Prairie Provinces	BC Equivalent	Minimum ($ thousand/km)	Maximum ($thousand/km)	Estimated Maximum for BC ($ thousand/km)
Plains	Plains-FSJ	4.5	5	5.8
Parkland	FSJ	6.5	7.5	8.6
Bush and Muskeg**	Fort Nelson	11	16	18
Foothills	Foothills	25	27.5	32
3-D		80	85	98

* For an average-sized program

** Winter costs

Note: Another source of cost data can be found in the paper *The Value of 3D Seismic in Today's Exploration Environment – In Canada and Around the World*. This paper, which presents costs for different plays (rather than by terrain) confirms that the cost range for 2D seismic is from $5000/km to $30,000/km (in the Foothills). The cost of 3D seismic can vary significantly from the $80-85,000/km presented by Sproule. Costs in the Foothills have been as low as $8000 because of sparse line spacings and other factors. Although the daily crew cost and intensity of operations for 3D seismic are higher than for 2D seismic, drilling success is increased substantially. This can bring the total surface disturbance and exploration costs down.

Operating (Ongoing) Costs

- N/A for geophysical exploration

Future Capital Costs

- Future capital requirements are mainly limited to geophysical services to re-process and re-interpret data, as wells are drilled and plays are developed.

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4.0 INFRASTRUCTURE

4.1 Overview

The main infrastructure requirements for geophysical exploration are transportation, energy, telecommunications and camps and support facilities.

Transportation

- BC and Alberta highways
- Secondary roads (logging, petroleum development)
- Temporary access, including winter roads
- Helicopter landing areas
- Commercial scheduled & chartered flights

Energy (gas/propane)

- On-site diesel generation (for camps)
- Fuel for transportation, recording and vibroseis trucks etc.

Telecommunication

- Land lines
- Cellular service
- Satellite phone; satellite-based GPS
- VHF radio
- Computer

Associated Businesses

- Goods supply – camp provisions
- Accommodation in nearby centres (e.g., Fort St. John)
- Repair and maintenance – vehicle, equipment

5.0 MARKET

The market demand for Geophysical Exploration contractors' services is driven by future expectations of gas and oil prices and the prospect of discovering new reserves. Geophysical activity is the first major capital expenditure in an exploration program. The duration of time between the first expenditure and collecting revenue can be two to ten years. If the perception of future pricing is low, geophysical expenditures may be the first to be reduced because they have an uncertain and delayed impact on cash flow.

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Market Segments

The market demand is almost exclusively driven by contracts issued by exploration and production companies.

Market Trends

Peak activity was in 1990 at 490 crew weeks. The recent level (2001) is at 167, 34% of peak level.

6.0 LABOUR FORCE

More than 32,000 people are working in the oil and gas industry in British Columbia. About 7,000 are actively engaged in exploration, production, development and related activities. The remaining 25,000 work in the downstream sector. Approximately 250 oil and gas service and production companies are working in the Northeast. Because Statistics Canada combines oil and gas labour figures with mining figures, it is difficult to break out numbers for oil and gas in most categories. In addition, some occupations are classified in general terms, based on their main activity (e.g., hauling gravel is under Transportation) and are not included under oil and gas statistics.

Geophysical exploration labour is measured in crew-weeks. In 2001, the number of crew-weeks was 167, down from a 10-year high of 283 in 1995. Based on 1997 activity levels presented in *The Value of 3D Seismic in Today's Exploration Environment – In Canada and Around the World* (see Investment Requirements), about 40 km of 2D seismic can be shot in one crew-week. The average cost of 2D and 3D seismic programs was $190,000 and $300,000 per crew-week, respectively. (Also see Capacity.)

In addition to the occupations listed below, various support workers, including mechanics and road construction workers, may be involved in geophysical exploration. The major occupations involved in conducting and supporting geophysical exploration include the following:

NOC Code	Occupation	Skill Level	Skills	Wages* ($/full year work)	Seasonality	Comments
2113	Geologist, geophysicist (project, specialist, mgr.)	A	University degree	$65-100,000+	Year-round	Primarily based in Calgary
2154	Professional land surveyor	A	See above	Est. $40-70,000	Primarily winter**	
2212	Geological & mineral tech. (including data tech.)	B	Specialized training, work experience.***	Est. $30-60,000	Primarily winter** (year-round for data technician)	Data technicians primarily based in Calgary

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NOC Code	Occupation	Skill Level	Skills	Wages* ($/full year work)	Seasonality	Comments
2271	Helicopter pilot	B	As above; pilot's, additional licences	Est. $50-100,000	Primarily winter**	
6242	Cook	B	Specialized training, work experience	Est. $30,000	Primarily winter**	
6642	Kitchen, food service helper	D	See above	Est. $20,000	Primarily winter**	
7610	Trades, helpers and labourers	D	Work demo. or on-the-job training	$7-11/hr plus subsistence, travel	Primarily winter	

* Wages will vary widely depending on commodity prices, crew availability, location, work conditions etc Therefore, with the exception of Code 2113 (based on the 2002 APEGGA salary survey), wages are estimated. The oil and gas industry typically pays higher than other industries because of winter, remote work conditions etc.

** May be year-round depending on where work is being conducted (i.e., in south or coastal areas).

*** Crew member(s) must also have safety, first-aid training.

7.0 CAPACITY

Capacity is viewed from two perspectives; firstly the resource capacity is the undiscovered hydrocarbon resource in British Columbia that will support future geophysical exploration. Secondly, the commercial capacity is the ability of the current geophysical exploration industry in British Columbia to support the market demand.

7.1 Resource Capacity

One-half to two-thirds of the land base of B.C. is underlain by sedimentary basins. Most of these basins are immature and little exploration work has been conducted on them. The current undiscovered resource potential in British Columbia is estimated to be 110 TCF (3.1 $10^{12}m^3$) of gas and 18 BBO (2.9 10^9m^3) of oil. This is the driver for future geophysical activity.

For perspective

- The current remaining reserve recognized by the Ministry of Energy and Mines is 252 10^9m^3 of natural gas and 25 10^6m^3 of oil. The undiscovered resource of natural gas is 12 times the current reserve.
- The total production from 1966 to 2001 was 502 10^9m^3 of natural gas and 91 10^6m^3 of oil. The undiscovered resource of natural gas is 6 times the production to date.

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- The magnitude of undiscovered resource potential indicates there is a good expectation that the current undiscovered resource potential is sufficient to support the current geophysical exploration industry.

7.2 Commercial Capacity

The current level of 167 crew weeks, is 34% of the 1990's peak of 490 crew-weeks. Although the commercial capacity of geophysical contractors appears to exceed the current demand, unutilized crews may have shifted to other industries. If activity levels increase in future, new crews will have to be gathered from a labour pool that other jurisdictions within North America will be drawing from. Geophysical capacity is mobile and thus capability can shift from Alberta to British Columbia. In periods of prolonged industry activity differences between the USA and Canada, geophysical capability can move between Canada and USA.

8.0 REGULATORY REGIME

8.1 Overview

This section summarizes the key local, provincial and federal regulatory requirements for conducting an oil and gas-related geophysical program. Provincial regulations are designed to address issues related to archeological sites, First Nations, fish and wildlife, forests, and watercourses. The regulations also attempt to minimize adverse effects on other commercial activities such as forestry, agriculture, the recreational use of land and transportation. Following is a list of acts that address many of these issues:

- *Petroleum and Natural Gas Act*, R.S.B.C. 1996, c. 361
- *Forest Act*, R.S.B.C. 1996, c. 157
- *Forest Practices Code of British Columbia Act*, R.S.B.C. 1996, c. 159
- *Heritage Conservation Act*, R.S.B.C. 1996, c. 187
- *Land Act*, R.S.B.C. 1996, c. 245
- *Waste Management Act*, R.S.B.C. 1996, c. 482
- *Water Act*, R.S.B.C. 1996, c. 483
- *Wildlife Act*, R.S.B.C. 1996, c. 488

Note that subsurface rights are granted under the *Petroleum and Natural Gas Act*, while surface rights on Crown land are granted under the *Land Act*.

In all geophysical activity a plan for public consultation and notification is required, as outlined in Section II of the Oil and Gas Commission's (the Commission's) *Public Involvement Guideline*. Landowners, occupants and trappers must be consulted, while residents and local government authorities near a line must be notified of the program.

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8.2 Provincial

The lead agency that administers geophysical activity is the Commission. Its mandate is to provide a single-window to review industry applications and ensure environmental economic and social impacts are addressed. The Ministry of Water, Land and Air Protection (MWLAP) and Ministry of Forests (MOF) may become involved if there are compliance- and enforcement-related issues regarding environmental damage and/or stream crossings (i.e., in reference to the *Water Act* and Forest Practices Code.) If additional regulatory agencies should be involved in an application review, the Commission will notify the applicant.

Although provincial tenure agreements include obligations to conduct exploration work, any company proposing to conduct geophysical operations in British Columbia must apply to the Commission for a geophysical licence and an approval to conduct geophysical exploration. Supporting materials listed in the *Checklist for Geophysical on Crown Land* (or *Checklist for Geophysical on Private Land*) and checklists for amendments and revisions must also be submitted to the Commission to ensure the proposed program complies with First Nations, public and legislative requirements. If no ground disturbance is involved, the amount of supporting material is reduced substantially; however, a *Checklist for Aeromagnetic/Gravity/Geochem Surveys* is to be submitted to ensure that First Nations and the public have been informed of the proposal. Supporting materials typically include an Application for Changes In and About a Stream and a Timber Harvesting and Field Assessment Application. Merchantable species must be utilized as directed in the Master Licence to Cut document and may not be disposed of by burning.

8.3 Private Land

- The company must apply obtain a permit from the owner or occupant of private land.
- The clearing of land and salvaging of timber must adhere to the requirements of the landowner.

8.4 First Nations

- The Commission's Aboriginal Relations and Land Use Branch coordinates field activities with First Nations and determines whether there will be potential treaty right infringements. Consultation is conducted with the band(s) claiming traditional rights in the area.

Note: If the land is within an Indian reserve, it is under federal jurisdiction and the Commission would not be involved.

8.5 Parks and Environmentally-Sensitive Areas

- Oil and gas geophysical activity is not allowed in parks in British Columbia
- On specified protected areas where there are grandparented tenure caveats, geophysical activity may be conducted to delineate the location of a drilling location. Grandparented tenure is generally tenure within a protected area that existed prior to the area being designated as protected.

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- Resource development is allowed on all Crown land outside parks, including "special management zones." In the Muskwa-Kechika Management Area in the North Foothills, pre-tenure plans precede posting tenure and drilling, to ensure that oil and gas development will be sensitive to important environmental and recreational values.

8.6 Federal Government

In addition to the acts listed below, the federal government is responsible for administering other acts, such as the *Migratory Birds Convention Act*, that may affect some oil and gas activity applications.

Navigable Waters Protection Act

- This Act regulates any activity in, around, under and over navigable waters, and is administered by the Canadian Coast Guard (CCG) of the Department of Fisheries and Oceans (DFO). Authorization under the Act is required for all stream crossings on navigable waters.

Fisheries Act

- Fisheries and Oceans Canada is responsible under the federal *Fisheries Act* to protect fish and fish habitat in "waters frequented by fish." For example, the Act prohibits the harmful alteration, disruption or destruction of fish habitat unless authorized by the Minister.
- By federal/provincial agreement, MWLAP is responsible for the management and protection of freshwater fish and anadromous fish stocks of steelhead, cutthroat trout, and Dolly Varden char.

Canadian Environmental Act

- The *Canadian Environmental Assessment Act* requires that environmental assessments be conducted for federal projects, projects involving federal funding, projects on federal lands and projects requiring a specific authorization or approval under specified sections of other federal acts.

8.7 Timing

The Commission tracks the timing of all applications and monitors the status of approvals from other provincial and federal bodies that are participating in the decision on a subject application. The review period for geophysical applications can range from a few days, if the proposed project is straightforward and in a developed area, to months, if it is in a sensitive and immature area.

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9.0 GOVERNMENT REVENUES

The oil and gas industry is a major contributor to the economy, at all levels of government. The total provincial revenue from Crown royalties and tenure dispositions reached a peak in 2001 at over $1.7 billion. (The amount for 2002 is expected to be lower because of lower commodity prices.) In addition to these revenue streams, the industry produces many indirect sources of revenue through employment (and the collection of personal income tax) and the purchase of good and services within British Columbia.

Royalties on gas, gas by-products and oil are the major provincial revenue sources for the oil and gas industry. These payments are global in nature and not attributable to any one activity (e.g., geophysical exploration or drilling). Royalties are presented in the building block for gathering and processing systems and facilities; however, there are other revenue sources that are collected from geophysical exploration. These are presented below.

9.1 Municipal

- Business Licence Fees
  - Variable – depends on community; typically $100/year
- Room Tax
  - Some municipalities charge an additional accommodation tax of 2%.

9.2 Provincial

- Application Fees
  - $500 (plus $0.75/ha/yr for years 1-3; increases to $3/ha/yr in year 8) - Class B permit
  - $300 - Annual Geophysical Licence; $1300 (plus $200/ha of line) – Application for a Geophysical Program (or revision)
- Corporate Income Taxes
  - 13.5% of taxable corporate income.
- Employee Income Taxes
  - Based on the average wage level in BC for full time employment ($32,000), a total of 22% is collected in federal and provincial personal income taxes. The Provincial tax component is typically 1/3 of this total.
- Petroleum and Natural Gas Rights
  - In 2001, $4.6 million was collected from P&NG permit dispositions. Fees and rentals contributed an additional $.1 million. (Note: Tenure bonus amounts vary from competition to competition.)
- Social Service Tax
  - Qualifying machinery and equipment used exclusively in the exploration, discovery or development of P&NG deposits are exempt.

In addition to the revenue sources listed above, other provincial taxes, such as the accommodation tax of 8% (e.g., applied when industry employees stay in Fort St. John) and

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provincial sales tax of 7.5% (on non-exempt goods), are collected as a result of oil and gas activity being conducted in British Columbia.

9.3 Federal

- Employee Income Taxes; Federal personal income tax is typically 2/3 of the total personal income tax collected.
- 26.12 % of taxable corporate income (i.e., for the average wage level).
- The federal sales tax is 7.0% and is charged on all goods and services.

10.0 INPUT-OUTPUT TABLE

The following table, based on 2001 data, summarizes the costs and revenue streams associated with producing gas in B.C. (Oil production is not illustrated here since gas production far exceeds oil production in the Province). Cost, revenue and production streams were discounted at 10% to determine unit costs (i.e., $/mcf). Provincial burdens and federal tax were relatively high because of high commodity prices.

Input costs in all categories have been increasing in the last five years, while pool sizes and average deliverability rates have been declining. Gas pools discovered from 1996 to 2001 ranged from 4 to 11 BCF in the Plains-Fort St. John region, from 4 to 18 BCF in the Fort Nelson region and from 19 to 28 BCF in the Foothills.

	Input ($/mcf)*								Output ($/mcf)		
Region	Bonus/ rental Cost	Geo. Explor.	Drilling Cost	Operating/ gathering cost	Processing cost	Provincial Royalties & Tax	Federal Tax	Input/ Pool ($million/ pool)	Gas Rev.	Liquids Rev.	Net Rev.
Plains-FSJ	0.04-0.37**	0.01-0.16	0.37-0.92	0.25-1.03	0.18-0.60	0.91-1.06	0.34-0.52	15-35	3.58-3.85	0.09-0.51	0.45-0.78
Deep Basin	0.13	0.08	1.55	0.43	0.22	0.88	0.29	32	3.74	0.03	0.24
Fort Nelson	0.11-0.23	0.04-0.14	0.61-0.87	0.46-0.54	0.40-0.64	0.90-0.94	0.26-0.38	13-57	3.59-3.68	0.01-0.09	0.33-0.52
Foothills (N)	0.10	0.06	1.12	0.67	0.44	0.92	0.28	68	3.71	0.12	0.25
Foothills (S)	0.10	0.13	0.72	0.50	1.24	0.69	0.19	100	3.76	-	0.18

* Costs are to plant exit only. Transmission tolls are not listed.

**Costs for south FSJ were exceptionally high. Bonus/rental costs in most areas within the Plains-FSJ region were around $0.20/mcf.

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11.0 REGIONAL COST VARIATIONS

11.1 Regions

British Columbia has resource regions located throughout much of the Province. Northeast B.C. has been the primary focus of oil and gas exploration and development for over 50 years. There are three main regions in the northeast – Plains-Fort St. John, Fort Nelson, Foothills (trending northwest from Pine River to the Muskwa-Kechika). These are associated with the Western Canada Sedimentary Basin (WCSB). Other basins in the Province are considered immature basins. The figure "British Columbia's Energy Resources," which can be found on the Ministry of Energy and Mines website at http://www.em.gov.bc.ca/dl/Oilgas/FuelingFuture/OGCBMmap_panel.jpg, shows the locations of the Western Canada Sedimentary Basin and immature basins.

11.2 Regional Data

Regional differences have been addressed in each building block if costs and other data were available. Where appropriate, the Deep Basin has been separated from the remainder of the Plains-Fort St. John region because of significant differences in pool depths and costs to develop these. In some tables, the Foothills region has been divided into north and south areas. Wells in the south are deeper, highly sour and more costly to develop than wells in the north. Data for immature basins is either very limited or non-existent, due to the complete lack of industry and system infrastructure in some of these basins. In particular, the costs to explore and develop oil and gas resources in the Whitehorse Trough and the Bowser Basin may be double those encountered in the South Foothills. Costs could also be high in basins in the south part of the Province, such as the Georgia Basin, where planning requirements and review periods are extensive.

11.3 Pre-tenure Planning

Pre-tenure plans are being developed by the Ministry of Sustainable Resource Management for the Muskwa-Kechika Management Area in the North Foothills region. These plans must be in place before tenures can be made available in special management zones within the management area. Plans identify sensitive resource values and objectives and strategies to support environmentally responsible development. Resource values include recreational, mineral and geothermal values, as well as environmental values.

The Foothills region has high wilderness and wildlife values but due to the relatively harsh climate conditions in the region, is more sensitive to oil and gas development than the Plains-Fort St. John and Fort Nelson regions. The same is true for many of the immature basins, which are also in mountainous areas.

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11.4 Evolution of Immature Basins to Mature Producing Regions

Immature basins are areas of the province in which government or industry geologists have identified the potential oil or gas resources but there is limited drilling, minimal production and very little pipeline infrastructure. The area is first explored by geophysical operations that determine subsurface structure by recording the reflection of sound waves. If the geophysical review of seismic data indicates a structure that could trap oil or natural gas, wells will be proposed to test the subsurface interpretation. Initial wells have a high degree of failure; only one well in ten to twenty wells may be productive.

Once a number of wells are deemed to be productive, the first pipeline infrastructure is built. This infrastructure is an important step in the maturation of a basin. The first successful wells prompt additional wells; the first pipelines promote new geological investigations of potential fields in proximity to the pipelines. The presence of pipelines improves exploration economics and promotes additional geophysical exploration and drilling. This leads to production success, which in turn reduces the operating costs of the infrastructure. The reduction in transportation fees promotes a higher level of exploration, resulting in a more mature basin. As geology is better understood, infill wells (wells located between existing wells) are drilled to recover additional reserves and accelerate production.

The life of a typical pool can vary in any region, from as few as five years, if water inflow problems occur, to over 30 years. To fully deplete gas pools and maintain production as the reservoir pressure declines, wells may be worked over (stimulated) and compression can be added. Oil wells can also be worked over to optimize production rates. The recovery of oil reserves can be enhanced by injecting water or carbon dioxide to maintain the reservoir pressure as oil is produced.

In the passage of 20 to 60+ years, the basin reserves are produced and depleted.

Immature basin development is influenced by a variety of factors including the:

- location of overlying parks
- ease of access into the areas
- proximity to existing infrastructure
- availability of corridors for infrastructure (e.g., pipelines)
- North American demand for gas supplies

Opportunities and challenges companies may face when exploring and developing immature basins, and currently undeveloped fields in the WCSB, are listed below.

11.5 Opportunities

- Significant untapped potential in Foothills, immature basins
- Strong demand – electric generation in the U.S., industrial and residential markets
- Transmission pipeline capacity
- Advances in technology for 3D(4D) seismic, drilling techniques etc.

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11.6 Challenges

- Need to replace production as fields in Plains-Fort St. John, Fort Nelson mature
- Lengthy approval process in the Foothills (and immature basins)
- Land use restrictions prevent multiple underlying zones from being developed
- Volatile commodity prices
- Rising exploration and development costs
- Smaller pools, high decline rates
- Need to drill deeper plays in undeveloped areas with a shorter drilling season
- Higher hydrogen sulphide concentrations in deeper plays in Foothills
- Gas plant constraints for sour gas
- Competition from other jurisdictions
- Kyoto Accord

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